Spatial-temporal variability of Submesoscale processes in the Bay of Bengal

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Abstract Using the Regional Ocean Modeling System (ROMS) data with two horizontal resolutions: a high-resolution(~1.6km,HR) that is partially resolve submesoscale, and a low-resolution (~7km, LR) that not resolve submesoscale, we focus on the spatiotemporal characteristics of submesoscale processes in the Bay of Bengal(BOB). Submesoscale processes are widely spread in upper mixed layer, especially in complicate topography. Their distributions vary greatly through the integrated period. To be more representative, the region of the central bay (Region A) and the eastern of Sri Lanka (Region B) have been analyzed. Both regions display conspicuous seasonality that submesoscale processes in fall and winter are strong, while those in region B are stronger than region A. The investigation of the generation mechanisms shows that the frontogenesis and mixed layer instabilities(MLIs) are the essential causes of the submesoscale seasonal changes. The horizontal density gradient present in the ocean is a prerequisite for the two mechanisms. More and stronger fronts are more conductive to the occurrence of submesoscale processes. Mixed layer depth(MLD) and mesoscale strain rate(MSR) are two important factors that regulate the seasonal variation of the submesoscale processes. Deep MLD and strong strain favor the generation of submesoscale processes via MLIs and frontogenesis. In general, the horizontal density gradient, MLD, and MSR are the main factors modulating the temporal variation of the submesoscale processes.

Observation

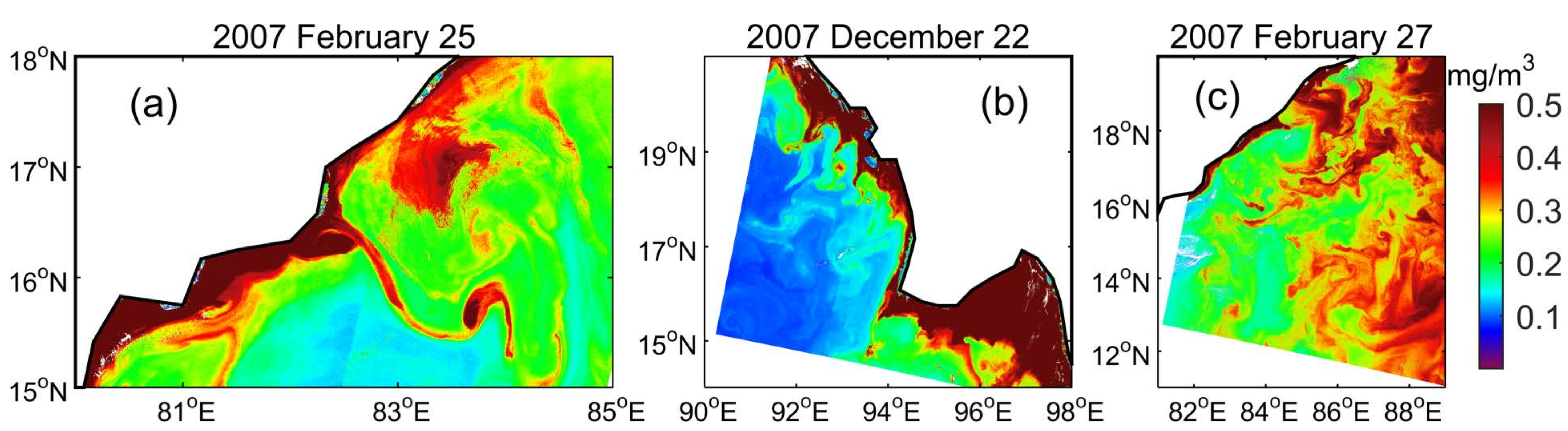

Figure.1. Daily 300m MERIS chlorophyll (mg/m^3) in the BOB.

Spatiotemporal Characteristics

Submesoscale processes: Rossby number ~O(1) (Ro=ζ/f)

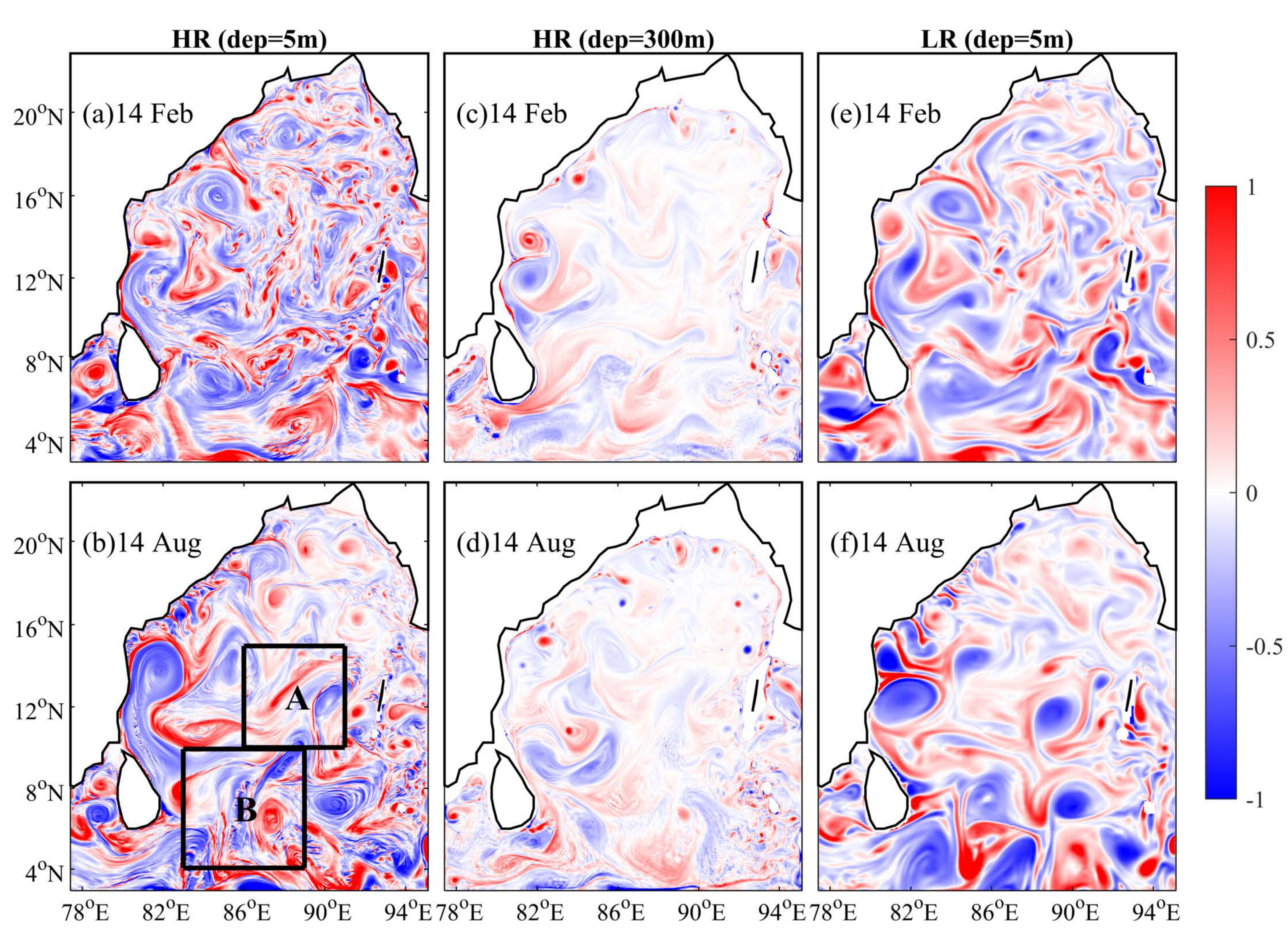

Figure.2. Spatial distribution of the Ro at 5m (left column and right column), 300m (middle), on February 14 (top row), on August 14 (bottom row) for HR (left, middle column), LR(right column). Two boxes represent the Region A and Region B, where diagnostics are computed next.

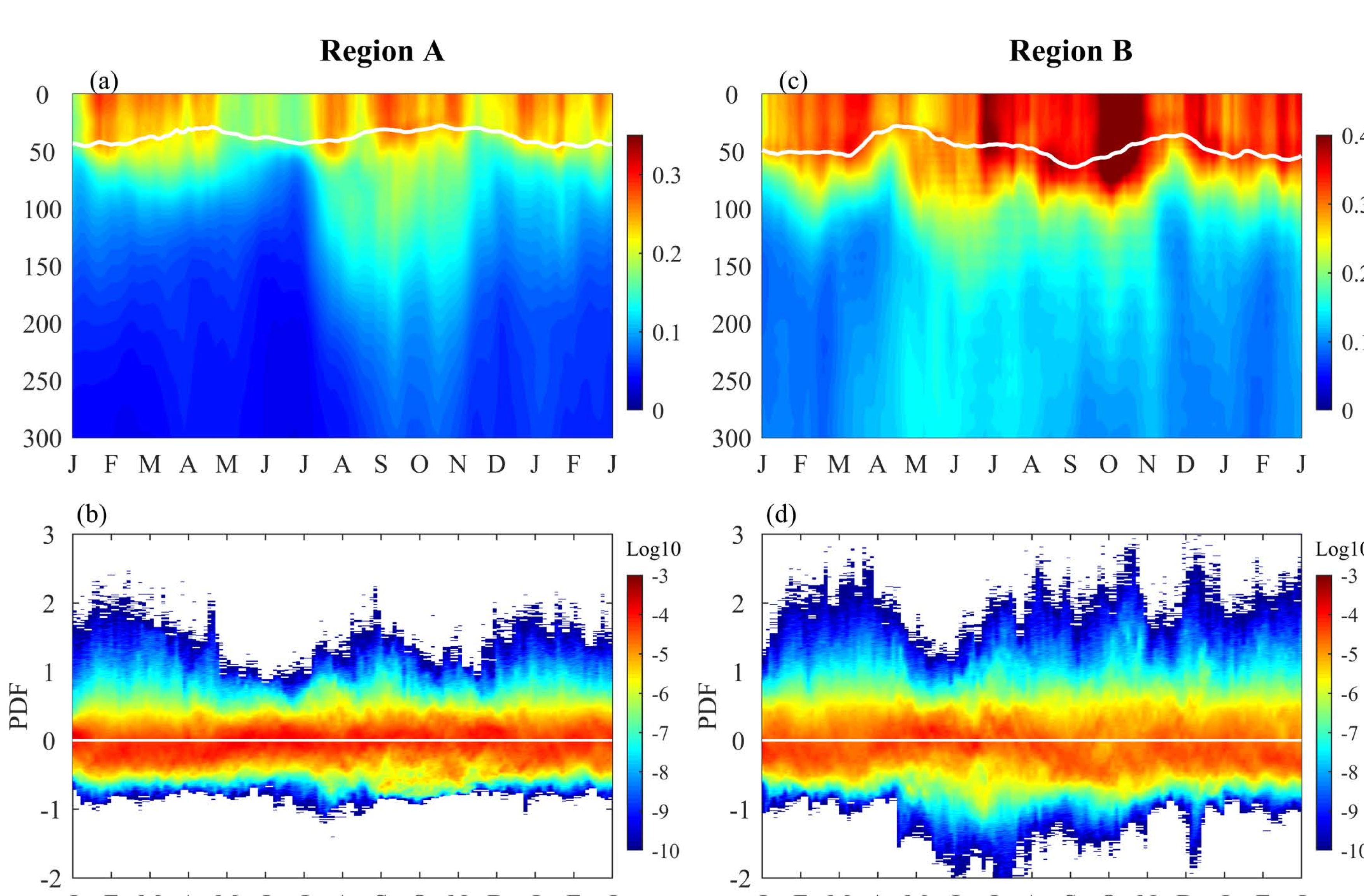

Figure.3. Time series of (a) region-averaged of |Ro| as a function of depth, and (b) the probability density function of Ro at 5m in region A. (c)-(d) are the same as (a)-(b), but in region B.

Generation mechanisms

Frontogenesis and mixed layer instabilities (MLIs) are known to be important processes in the generation of submesoscale features. For a number of diagnostics, we choose 15km and 30km to separate flow into mesoscale (MS, over-bar) and submesoscale (SM, prime) components in region A and region B, respectively.

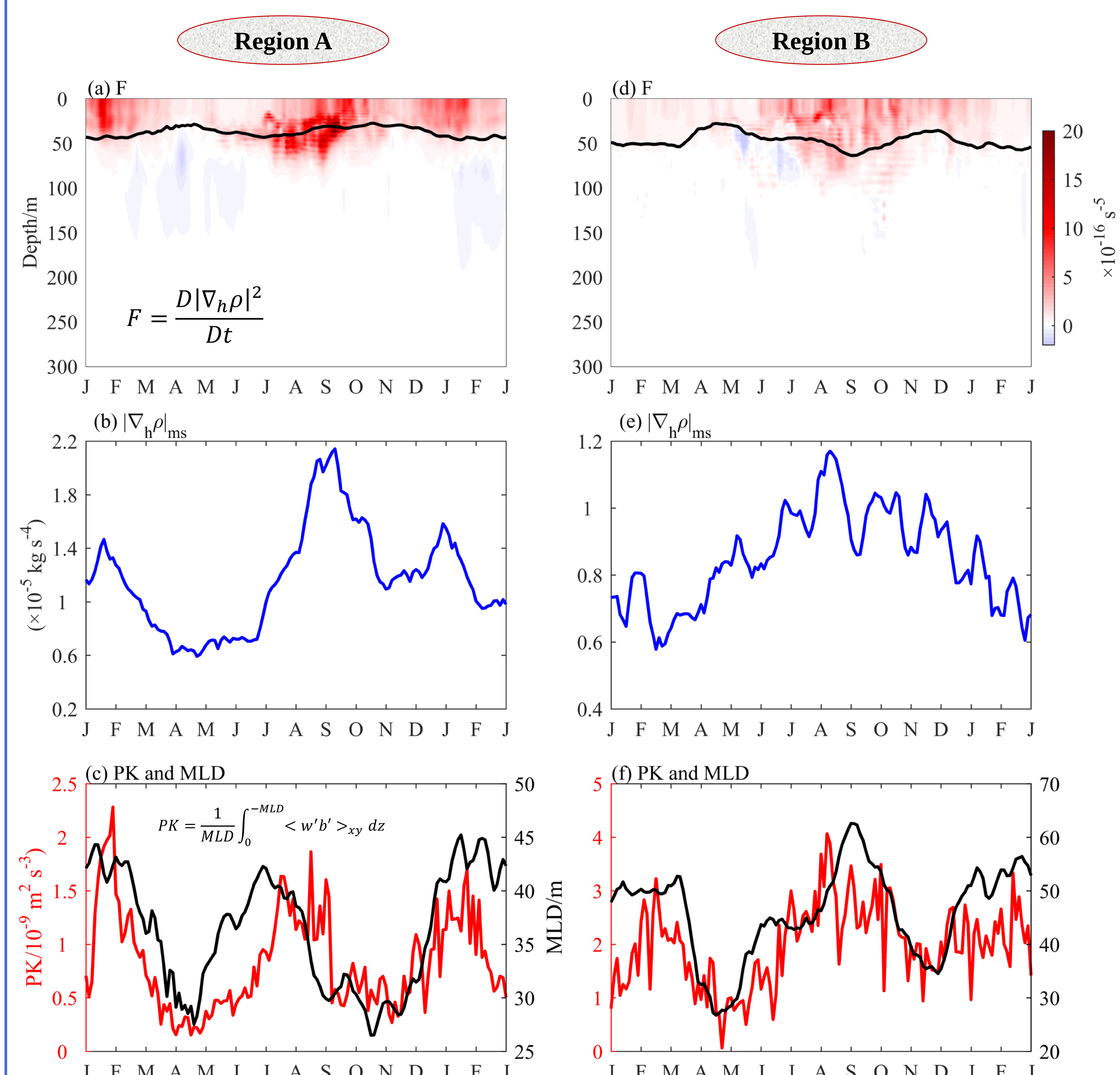

Figure.4. Time series of (a) region-mean of the frontogenesis F as a function of depth (the black denotes the region-averaged MLD), (b) region-mean horizontal density gradient integrated over MLD, (c) the rate of conversion of APE to EKE, PK (red) and MLD (black) in region A. (d)-(f) are the same as (a)-(c), but in region B.

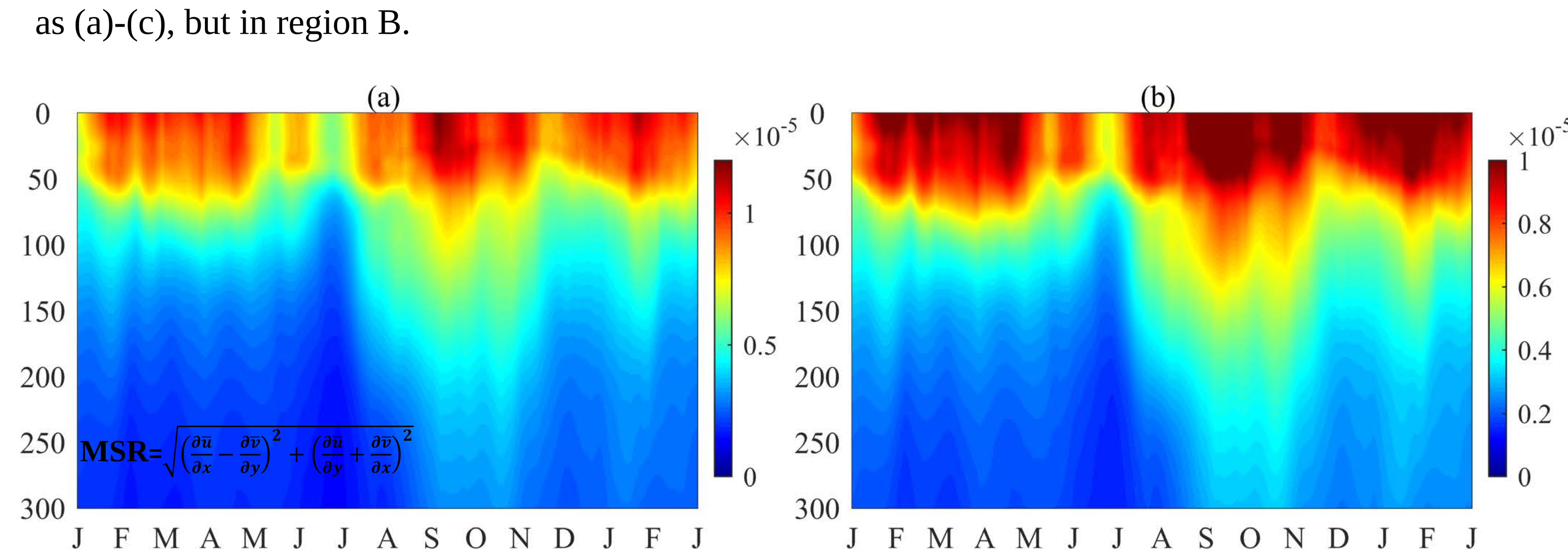

Figure.5. Time evolution of region-averaged mesoscale strain rate (MSR) as a function of depth (s^{-1}).

Conclusion:

- SM are ubiquitous in the BOB, especially in the mixed layer and the prominent topography.
- SM are strong in fall and winter for both regions, while those in region B are stronger than that in region B.
- MLIs and frontogenesis are essential for the variability of SM .
- $|\nabla_h \rho|$, MLD, and MSR are the main factors modulating the temporal variation of SM.